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Implementing High Productivity Freight Vehicles in Urban Areas

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Abstract

Many urban areas are experiencing growing levels of traffic congestion and increased freight demand due to population growth, globalization and contemporary logistics systems. High Productivity Freight Vehicles (HPFVs) are large combination vehicles that offer significant benefits for lowering costs, improving safety and protecting the environment by reducing the number of truck movements in cities that would otherwise be needed. This paper describes how HPFV are being implemented in Australian urban areas within the Performance Based Standards (PBS) framework to allow better use of existing urban freight networks. PBS is a flexible non-prescription framework for regulating the weight and dimensions as well as network access of road freight vehicles. This paper presents details of case studies used to estimate the productivity gains from operating PBS vehicles in urban areas. A range of PBS vehicles have been identified as being suitable for urban freight operations including Super B-doubles and rigid trucks. This paper demonstrates how the productivity gains from PBS vehicles operating in urban areas can be estimated. The results of simulations of a number of freight networks for specific commodities are presented. The analysis presented shows that substantial benefits can be achieved by the take-up of PBS vehicles in urban freight networks. Case studies show a lowering of several key freight exposure metrics, which involve kilometres, trips, task travel times and vehicle numbers.
A description of the HPFV route assessment process as well as the Intelligent Access Program (IAP) is also presented. The route assessment process is used to examine the road geometry and pavement conditions for the first and last mile access. The IAP uses the Global Position System (i.e. GPS) to monitor heavy vehicles' compliance with access conditions.

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Keywords: urban freight transport; High Productivity Freight Vehicles (HPFVs); urban freight networks; Performance Based Standards Vehicles;

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1. Introduction

Growing levels of freight demand are contributing to rising levels of congestion in many cities. Increasing freight demand from imports as well as exports is particularly significant in cities near ports, intermodal terminals and distribution centres. There is also a trend in urban distribution systems for more frequent deliveries with smaller loads. These factors have led to increased social and health problems from air pollution, noise and safety.

A major challenge for both governments and industry is how to increase the productivity of urban freight systems since this will reduce the price of goods as well as lower the social and environmental costs. Designing freight vehicles to better match the type of vehicle used to the goods transported and the road environment has been identified as a major initiative for reducing the vehicle miles of travel required to service the growing urban freight task in Australian cities (NTC, 2010).

1.1. Performance Based Standards Vehicles

The Performance Based Standards (PBS) scheme operating in Australia was implemented to increase the productivity, efficiency and safety of road freight vehicles. PBS allows innovative vehicle designs by specifying what vehicles must be able to achieve in terms of their safety and infrastructure protection performance in contrast to prescriptive limits on their physical weights and dimensions (OECD, 1995, Di Chirstoforo et al, 2006, NTC, 2008).

Safety criteria for trucks have been linked to different levels of network access to ensure that there is a clear match between a road's geometric and pavement standards and vehicle's mass and operating standards. Currently four classes of roads have been defined, level 1 for passenger cars and single articulated trucks, level 2 for B-doubles, level 3 for double road trains (Type I) and level 4 for triple road trains (Type II), (NTC, 2007).

A number of PBS vehicle types have been identified as having potential productivity gains in urban freight operations (Hassall and Thompson, 2011), including two axle and three axle rigid trucks, Super B Doubles, A Doubles and single semi-trailers (19m-20m). Under PBS rigid trucks can add 1 meter to their body length for volumetric operations, as well as 3 axle rigids extending dimension to under 15 meters with a fourth axle. Super B-doubles can replace single articulated trucks in urban areas largely associated with container transport attractive from both the hire and reward and large ancillary operators. Two axle and three axle rigid trucks as well as single semi-trailers operating under PBS are able to operate on general access roads (level 1). However, Super B Doubles and A Doubles are restricted to level 2B roads, but even so these are becoming common in urban areas in Australia.

1.2. Urban Freight Networks

Usage of trucks depends on what commodities are carried, and the types of freight networks the vehicles are used for. Urban freight networks are diverse in nature. Generally there are two types of urban truck tasks. These are often described as multi customer pick-up or put-down operations, or depot to depot transfers, commonly referred to as interchange activity. Vehicles in some more complex operations may do both. For example, the delivery pattern of a small express parcel truck delivering several bags of express articles to several clients in a metropolitan area is not comparable to an articulated truck transferring shipping containers between a manufacturing plant and a port.

Vehicles deliver goods to specific locations in their respective types of networks. In urban areas, quite dense urban networks with several hundred customers are common. There has been limited research to date analysing truck routes in urban areas (Holguin-Veras and Patil, 2005). When fleet operations managers incorporate PBS vehicles into their fleets due to the enhanced capability of these vehicles, extra volume and/or extra mass can be transported usually allowing fewer trips, thus fewer kilometres and fewer trucks to deliver goods. Utilizing PBS vehicles in a network will almost certainly lead to a reduction in total network kilometres and the number of vehicles needed to undertake deliveries. Typically the metrics that reflect the physical productivity of PBS adoption are, total kilometres travelled, total hours of operation and individual fleet vehicle numbers.

2. Super B-Double Case Studies

Super B-doubles are currently emerging from the existing single semi-trailer population (Figure 1). A high take-up is expected from both hire and reward and large ancillary operators in the future. The Super B-Double is predominantly an urban or short distance operating vehicle. It is especially useful for container movements, providing capacity for two, 40 foot shipping containers.

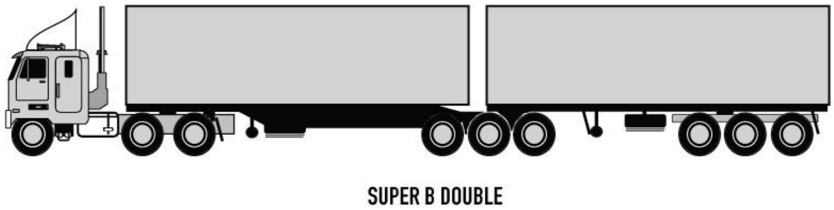


Figure 1 B-Double

2.1. Urban Container Transport

An investigation was conducted of the productivity benefits of Super B Doubles transporting containers between large freight precincts in Melbourne (Figure 2).

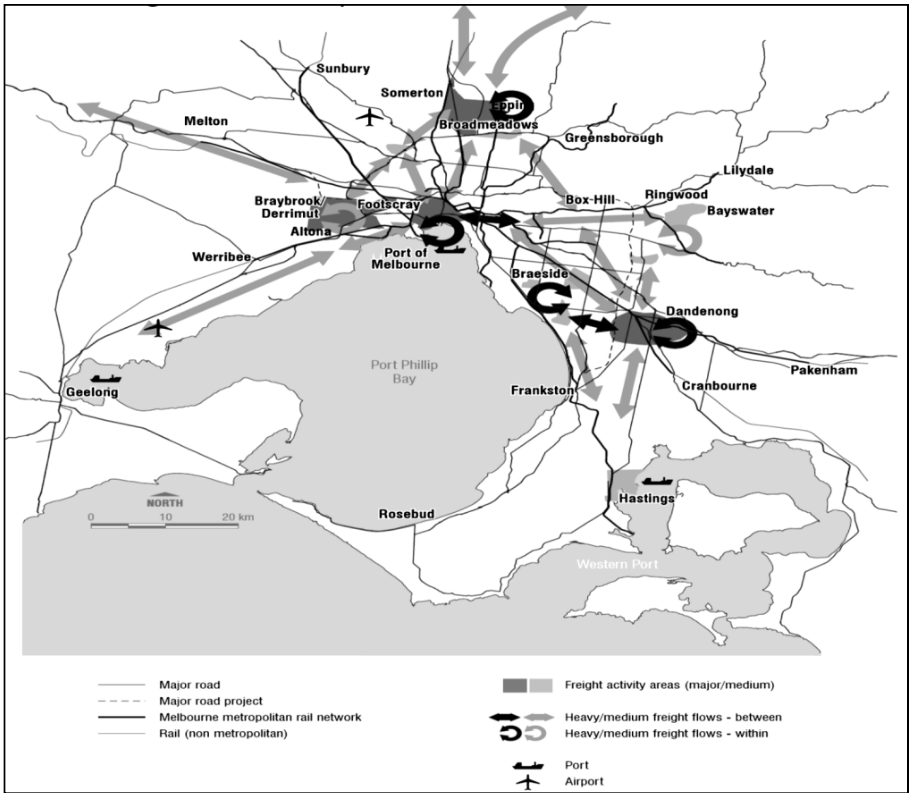


Figure 2 Melbourne's largest freight precincts. Source: DOT, 2008

This simulation was based on 33% of container traffic tonnage task between the ten most active origin and destination nodes in Melbourne's metropolitan area in the State of Victoria. The initial vehicles were assumed to be effectively operated over four periods a day from early morning to a later off peak evening time. The impact of these vehicles is significant as standard B-doubles have had little impact on the city port container task (Table 1). At the time that the simulation was undertaken around some 6% of movement around the Port of Melbourne and Dynon precincts were performed by B-doubles. The design of this task also allowed a high degree of empty container returns with more consolidated backhaul loads.

Table 1 Super B Double Urban Container Case Study Summary of Performance

270 Single Articulated Vehicles to 120 Super B-doubles	-55.5%
1626 to 724 trips	-55.4%
Load Utilization: Single articulated Vehicles	65%
Load Utilization Super B-doubles	67%

2.2. To and From Container Port

The growth in demand at container ports has also generated scheduling and queuing problems for trucks. There are inefficiencies as well in the business rules for truck behaviour at container ports. Generally single pickups or put downs are allowed. This makes for upwards of 70% of truck movement to Ports are involved in a single trip load, be it a single container pickup or dropping off an empty container. Although virtual container parks are sometime off in Australia, multi-container put downs and pickups could be initiated in the future. The following scenario looks at a comparison of multi-drop container put down and multi-container pick up.

In this case study there are 17 port customers. They dispatch two containers to the port each day (16 hours shift time window) and have two containers delivered to their premises during the day. The containers are 60% TEUs and 40% FEUs. The customers lie on approximate radial boundaries from the port of 10 kms, 20kms and 30kms respectively (Figure 3).

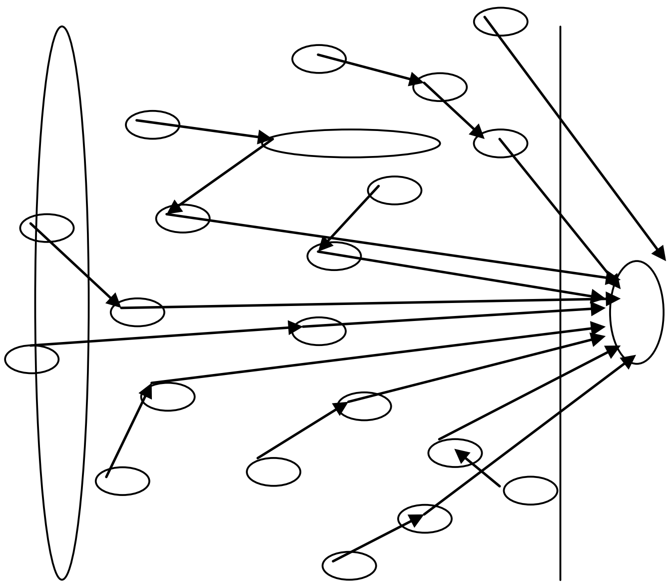


Figure 3 Forward Leg Container Trips to Port: Single Articulated Truck

The task of the double pickup and drop-off can be undertaken with either a single articulated vehicle or a Super B-Double. A single articulated vehicle can pick up either 2 TEUs or 1 FEU. A Super B-Double can load 2 FEUs or 4 TEUs or 1 FEU and 2 TEUs (Figure 4).

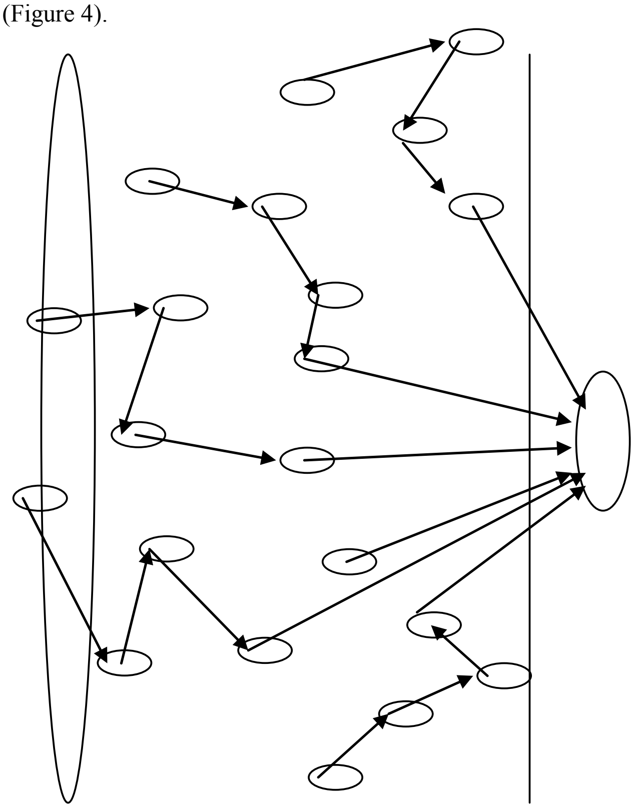


Figure 4 Forward Leg Container Trips to Port: Super B-Double

The main findings are that the introduction of the Super B-Double has a substantial reduction of truck trips to/from the port (Table 2). Total trips are reduced by 50%. Total urban kilometres are reduced by 25% and within an optimized closed network trucks numbers can be reduced by 25%.

Table 2 Performance of Super B-Doubles to and from Port

	Single	*Super B Double*	*Change %*
Directional Trips	24	12	-50.0%
Kilometres	708	530.4	-25.1%
Vehicles	4	3	-25.0%
On duty hours	26.5	22	-17.0%
Ave kms per trip duty	29.5	44.2	49.8%
Other Data			
Container Mix	60% TEU	40% FEU	
Customers	**17**		
Time window	8 hour total shift operation		

3. Rigid Vehicle Case Studies

Since rigid vehicles out number articulated vehicles in Australia by 17 to 3 respectively, even small productivity gains for rigid vehicles translate to a considerable amount of productivity gain for total urban freight operations.

3.1. Rigid Parcel Vehicle

In July 2006 Australia's largest network transport operator proposed an over dimensional rigid truck for predominantly urban operations, but also available on regional shuttle work. This vehicle is 14.85 meters in length and has a GVM of 28.0 tonnes (Figure 5).

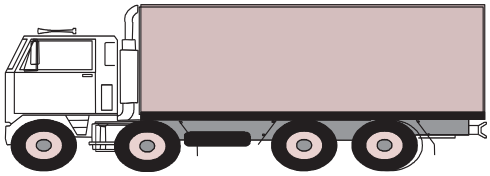


Figure 5 Urban Rigid PBS 4 axle Rigid Vehicle

The case study analysed was an intensive 6.5 hour window that occurs across three levels of operations: Processing Centre interchange, Processing Centre to Urban Hub transfers, and Urban Hub to Delivery Centre dispatches. Currently the mix of vehicles comprises some articulated vehicles, significant numbers of heavy 3 axle rigid vehicles, and some 15 and 11.9 tone two axle rigid vehicles. Figure 6 presents a stylized version of the network for which the analysis has been undertaken.

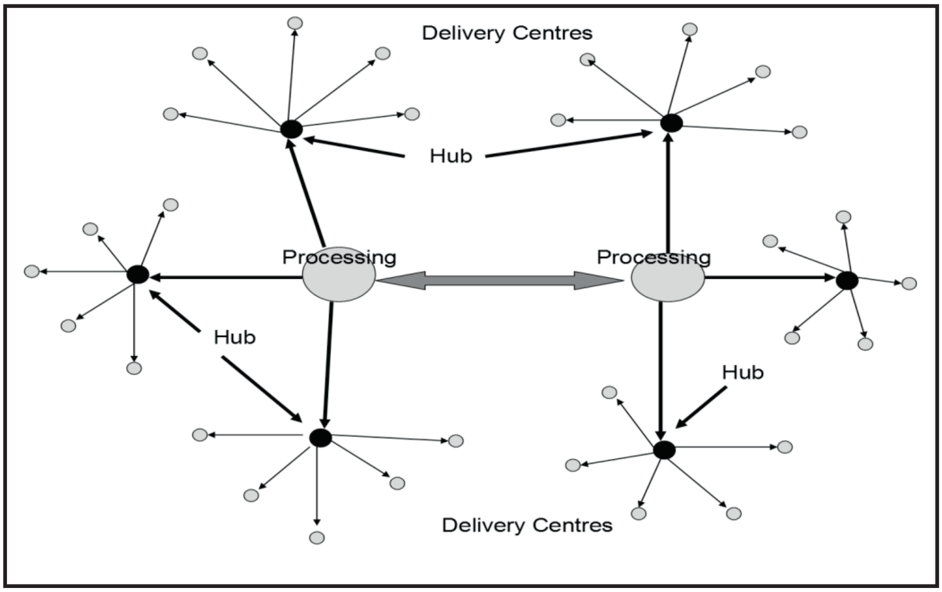


Figure 6 Parcels Network (Melbourne) – Stylized Layout of Major Nodes

This case study has significant higher benefits within this working period examined which is a working shift period that occurs for the operator of this network between the hours of midnight and 6.30am each weekday. That is, the time window spans only a 6.5 hour shift. Certainly the urban exposure metrics of trips, vehicle numbers and urban kilometres exhibit very generous savings (Table 3). The cost perspective also has potentially large palatability for the operator and customers, with benefits just lower than 20%.

Table 3 Urban Rigid Parcel Vehicle

Whole Trip savings	16.6% per day
Kilometre savings (3780 km to 2768km per daily shift)	26.7% per day
Cost Savings	19.4% per day
Vehicle Fleet Reduction (44 vehicles to 28 vehicles)	36% of fleet

3.2. Rigid Tanker

A case study was undertaken in the commodity stream of urban tanker operations. Using a variation of the urban rigid truck a significant improvement could be made to the distribution network using a 14.85 m 4 axle rigid tanker. The PBS vehicle in this case was an over dimensional 4 axles rigid tanker, with length 14.85 m, height 4.1m, GVM to 28 tonnes. This urban short tanker concept is useful in dense urban operations. The main reason for its possible adoption is access to customer locations requiring small volume drop-offs that cannot be serviced by a 19 meter articulated vehicle.

In this case study the customer network was based on a large current Sydney distribution network. A single depot services a fleet of 8 articulated tankers, and 8 small rigid tankers who distribute to some 103 customers daily. By seeding the concept 4 axle rigid vehicle tanker into the fleet the extra volume capacity allows for a greater number of customers to be served per dispatch run before returning to base to refill. This minimizes empty backhaul running. The extra customers served per driver run diminishes the exposure on articulated tankers number of fleet vehicles and also minimizes the urban kilometres performed by the existing articulated vehicles.

The vehicles generally operate during retail operating hours, namely weekdays 8am to 8pm. The extra 5 tonnes of liquid cargo allowed with this vehicle configuration has significant benefits (Table 4).

Table 4 Key Findings PBS Urban Rigid Tanker

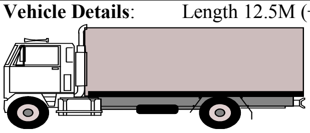
Net Load Capacity increase (per rigid vehicle) (9.8 Tonnes to 14.8 Tonnes)	51.0%
Reduction of Articulated Urban kilometres	6.4%
Increase in Rigid Truck Kilometres	20.5%
Change in Total kilometres	5.7%
Customers serviced by Rigid PBS Tanker	5.9%
Decrease in Articulated Truck hours travel	12.5%
Fleet reduction in tanker vehicles (16 to 14)	12.5 %
Total Fleet Cost Reduction	10.25%

This case study largely revolves around the substitution of PBS rigid vehicles for existing articulated tankers. It is a case study for a particular state capital city network and despite the modest cost improvement -10%, there is also a 1/8th reduction in fleet numbers and a modest increase in urban articulated kilometres for this network. Where access is a problem this 4 axle tanker vehicle may be considerably more useful than an articulated semi-trailer tanker.

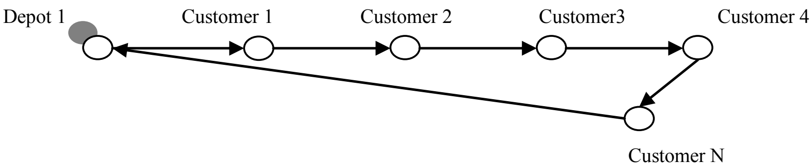
3.3. Two and Three Axle Rigid Trucks

Significant potential productivity gains were estimated balanced across the factors of length, if a common heavy 2 (or 3) axle rigid truck were to be allowed an extra meter in length and, an extra 1 tone of payload (Figures 7 and 8). For both these cases the impact of “small” regulatory and dimensional increases in mass and length, assuming only small access restrictions are encountered, generates a productivity benefit that can make a significant impact into the future growth of an urban trucking task. For these two hypothetical and simple networks, the product benefits are 14.1% and 10.4% respectively. Such gains are very significant for urban transport operators from both an efficiency, and potentially, a profitability perspective. In fact this dimensional increase, 1 meter length and 1 one tone extra load capacity, when modeled would substantially dampen the predicted growth in urban rigid truck kilometer in Australia over the next 20 years.

Vehicle Details: Length 12.5M (+1M) Height 4.3M, Mass 15 T GVM (+1T)



Network Configuration:

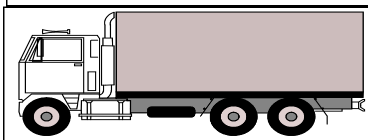


Enhanced Productivity:

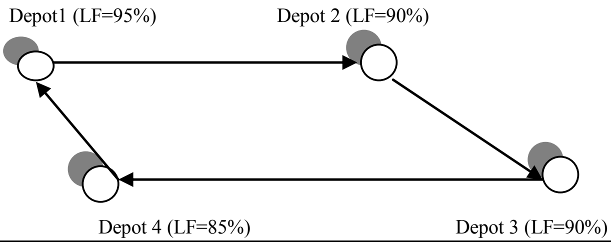
Mass benefit	Network Factor	Mass weighting	
12.5%	0.83	0.4	= 4.17% +
Length Benefit	Network Factor	Length Weighting	
20%	0.83	0.6	= 9.96%
Total Operational Productivity			**= 14.13%**

Figure 7 Single drops network (2 axle truck)

Vehicle Details: Length 12.5M (+1M) Height 4.3M, Mass 22.5 T GVM (+1T)



Network Configuration: "Multi Depot Drops"



Enhanced Productivity:

Mass benefit	Network Factor	Mass Weighting	
9.909%	0.9	0.4	= 3.272% +
Length Benefit	Network Factor	Length Weighting	
14.28%	0.9	0.6	= 7.771%
Total Operational Productivity			**= 10.43%**

Figure 8 Multi depot Network (3 Axle Rigid Truck)

3.4. 4 Axle Rigid Truck

A concept configuration of a heavy 4 axle rigid PBS delivery vehicle has been proposed that has double the load of the standard heavy 2 axle rigid truck and with enhanced steering features it has the same access potential and turning circle as the heavy 3 axle rigid truck. The benefits from this particular vehicle for the Postal Corporation, as it is phased into the fleet across a period of a 7 year vehicle replacement cycle would be: a load productivity benefit of 37.7%, a kilometer saving of 20% of total rigid vehicle urban kilometres (Table 5). The actual truck number savings are almost proportional to the kilometer savings, and estimated as a saving of about 19% of total urban rigid vehicle assets.

Table 5 Desktop and simulation sensitivity analysis for the Urban Concept Vehicle:

3-Axle Rigid Truck (28ULD)				**Heavy 2-Axle Rigid Truck (20ULD)**			
Million Kilometres per annum = 17.9m				**Million Kilometres per annum = 10.1m**			
Operation factor		**Units = 203**		**Operations Factor**		**Units =169**	
0.3	**Milk Run**			**0.9**	**Milk Run**		
		Load Productivity	0.4286			Load Productivity	1.0000
Hops per duty	**8**	Access	0.6400	**Hops per duty**	**9**	Access	0.4129
		kms	-0.2222			kms	-0.1818
0.7	**Interchange**			**0.1**	**Interchange**		
		Load productivity	0.4286			Load productivity	1.0000
Hops per duty	**5**	Access factor	0.7800	**Hops per duty**	**5**	Access factor	0.7800
		kms	-0.2000			kms	-0.2000
	28ULD prod factor		**0.316**	20ULD prod factor			**0.450**
	Weighted Productivity			**37.7%**			
	Est Km Reduction	20.6%					
	Truck Numbers = -18.36%						
	AVERAGE WEIGHTED Rigid truck km reduction = 19.84%						
	Estimated Total Km Reduction				**= 5.55 Million kms**		

4. Analyzing the Operations of Australian PBS Vehicles

During 2013 three surveys of Australian PBS vehicles were undertaken by the Industrial Logistics Institute and the National Truck Accident Research Centre. The surveys examined the direct productivity, safety and environmental benefits of PBS vehicles as well as the economic flow-on benefits economic benefits, savings in freight exposure and possible pavement benefits of Australian PBS vehicles.

The take-up, operations and productivity of these new vehicle types described in Table 6, reflecting the various articulated and rigid vehicles combinations that were surveyed for the study. In all there were ten truck types. These ranged from single rigid combinations, to 4 trailer combination articulated vehicles.

Table 6 Study Combinations examined – 2013 PBS Survey

Vehicle Type	Abbreviation	Description
1. Single Semi Trailer 6 or 7 axles	6/7AA	Extendable to 20m 6-axle semi trailer or twin steer 7 axle semi trailers. Can operate on Higher Mass Limits (HML). Both configurations are reflected in the survey. Quad axles can exist in this class.
2. Enhanced B-Double	EBD	B-Double with either quad axle trailer groups or length up to 30m or both. Up to 11 axles. Can be operate on HML
3. Super B-Double	SBD	B-Double up to 30m with equivalent length for A and B trailers. Can operate on HML.
4. A-Double	AD	An A-Double can be considered a mini Type I Road Train. It is usually less than

		30m long, with 11 or 12 axles. Can operate on HML
5. B-Triple	BT	Triple trailer combination, up to 36.5m. 5 axle groups, 12 to 14 axles. Can operate under HML. BB, AB and BA configurations are operational.
6. Quad Trailer Combination	QT	Articulated combination with 4 trailers. 7 axle groups, with 17 or more axles. Various configurations such as BAB or AAB variations are usual. Often referred to as a double B-Double. Combinations are over 33m and can operate on HML.
7. Truck and 3 Axle Dog Trailer	HR3ATD	Three-axle truck and three-axle dog trailer. 6 axles, 4 axle groups. GCM over 42.5 tonnes. Can operate under HML.. Usually 19m
8. Truck and 4 Axle Dog Trailer	HR4ATD	Three-axle truck and four-axle dog trailer. 7 axles, 4 axle groups. GCM over 42.5 tonnes. Can operate under HML. Usually 19 - 20m
9. Truck and 5 Axle Dog Trailer	HR5ATD	Three-axle truck and five-axle dog trailer. 8 axles, 4 axle groups. GCM over 42.5 tonnes. Can operate under HML Usually 20 – 22 m
10.Truck and 6 Axle Dog Trailer	HR6ATD	Three-axle truck and six-axle dog trailer. 9 axles, 4 axle groups. GCM over 42.5 tonnes. Can operate under HML. Up to 26m.

The study began in early 2013 and was completed in 2014. From the estimated PBS vehicle population of 2270 vehicles some 625 vehicles contributed data to the survey. This reflected positive responses from 65 surveyed fleets out of the total survey population of 213 fleets. The vehicle configurations are listed in Table 7. Artistic representations of the vehicles design can be found in Appendix A.

The highest appearing vehicle type was the 3 axle rigid truck with a 4 axle ‘dog’ trailer combination. Single semi trailer combinations of length 20 metres or twin steers axle configurations, and B-Triples were the second and third most popularly used vehicles in the survey.

Table 7 Number of PBS Vehicles surveyed by truck configuration

PBS Type	*Description*	*Surveyed Vehicle Numbers*
6/7AA	Enhanced 6 or 7 Axle Semi Trailer	91
EBD	Enhanced B-double	73
SBD	Super B-double	37
AD	A-Double	67
BT	B-Triple	89
Quad Trailer	Quad trailer combinations	35
HR3ATD	Heavy Rigid and 3 axle Dog Trailer	19
HR4ATD	Heavy Rigid and 4 axle Dog Trailer	164
HR5ATD	Heavy Rigid and 5 axle Dog Trailer	29
HR6ATD	Heavy Rigid and 6 axle Dog Trailer	20
HR 8X4	Heavy Rigid 8 x 4	1
Total		625

At the current time the major highways in Australia connecting the four largest Eastern seaboard cities: Brisbane, Sydney, Melbourne and Adelaide are not open to all PBS combinations, namely B-Triples and A-Doubles. This has resulted in only a small take-up in the use of PBS vehicles for general freight.

The high number of rigid truck combinations is reflected in the high use in the quarry, soil and sand industries. Agricultural commodities, grain and fertilizers formed the second largest commodity groups carried by PBS vehicles (Figure 9).

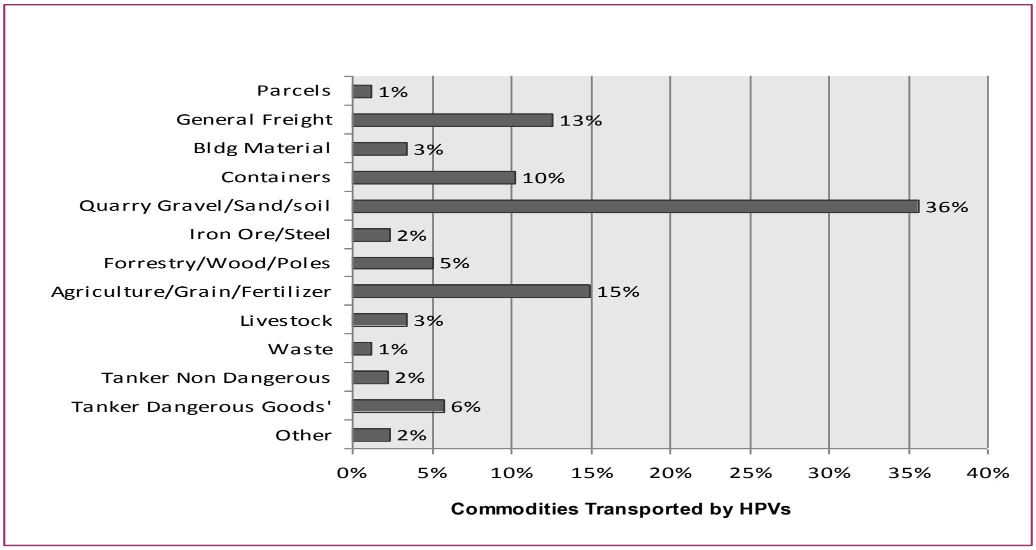


Figure 9 Commodities carried by Australian PBS vehicles

4.1. Urban Aspects of Australian PBS Vehicles

An analysis of the areas of the operations of PBS vehicles revealed that 10% were urban only, 20% were outer urban to provincial cities and 70% were in other areas. From a fleet perspective some 43 per cent of fleets were operating in urban and outer urban regions to provincial city locations. In both cases represented, a significant PBS task is 'regional linehaul' which moves goods from regional provincial cities to regional and remote locations in Australia.

4.2. Benefits of Australian PBS Vehicles

The estimated kilometre and vehicle savings are outlined in Table 8. The factors can be applied to the fleet vehicle numbers (PBS-VF) and to freight kilometres travelled (PBS-KF).

Table 8 Vehicle and kilometre factors for selected HPFVs

Vehicle Type	Vehicle Saving	PBS-VF	KM Saving	PBS-KF
EBD	0.349	0.651	0.273	0.727
SBD	0.474	0.526	0.365	0.635
A-Double	0.377	0.623	0.315	0.685
B-Triple	0.347	0.653	0.325	0.675
Quad Trailer	0.419	0.581	0.405	0.595
HR3ATD	0.166	0.834	0.129	0.871
HR4ATD	0.258	0.742	0.221	0.779
HR5ATD	0.306	0.694	0.264	0.736
HR6ATD	0.345	0.655	0.300	0.700

4.3. The take-up and benefits of Australian PBS Vehicles

Three growth forecasts were examined in the national PBS study (Figure 10). These were based on the rate of opening of the major national highways to A-Double and B-Triple PBS combinations. At the current time the long term take-up of PBS vehicles is tracking to the high scenario forecast. The financial operational benefits of PBS vehicles are presented in Table 9. The PBS truck benefits approximate $11 billion. The safety, insurance and environmental and flow-on economic benefits are estimated as 55 per cent of the operational benefit again.

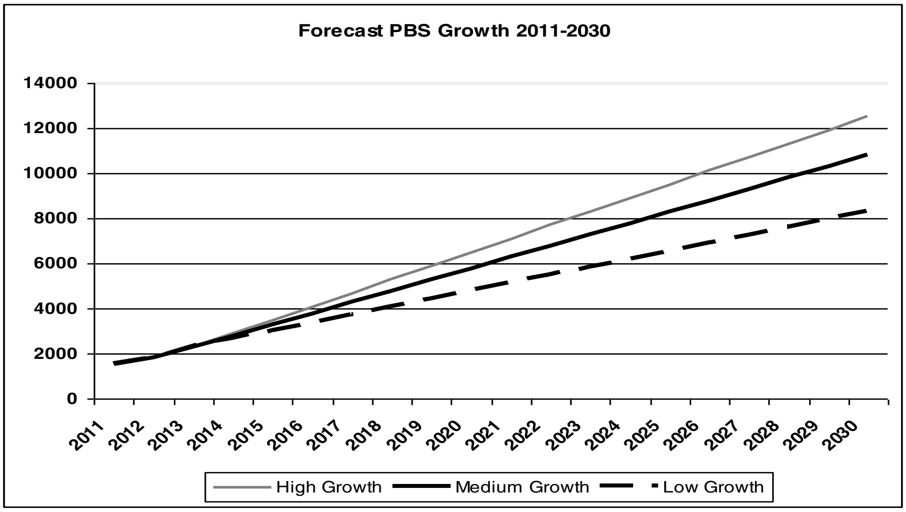


Figure 10 Forecasts of PBS vehicles by 2030

Table 9 Forecast Operational Benefits and PBS Population by 2030

HPV Vehicle type	Forecast nominal PBS Operational Benefits to 2030 ($m)[1]	Total PBS Vehicles at 2013[2]	High Estimate of PBS Vehicles 2030
3AR > 42.5T	$166	<100	376
4AR > 42.5T	$1,461	<510	2172
5AR	$739	<80	802
6AR	$794	<80	472
EBD*	$614	<50	291
6/7AA	$1,249	<200	3079
QT	$315	<30	355
SBD	$526	<120	879
BT	$2,254	<400	1545
AD	$2,843	<400	1621
Bus 1 & 2	$141	<300	1104
Total	$11,101	<2270.	12694

Note: 1. High Scenario; 2. Estimated HPV population as at January 2013 Estimated at 2269 vehicles.

As stated previously some 10 per cent of these benefits are from within urban areas with a further 20 per cent of the benefit being gain through the operations from and to outer urban areas of major cities travelling to provincial cities.

4.4. High Productivity Freight Vehicles

Recently the Victorian Government released a policy relating to extending access for High Productivity Freight Vehicles (HPFVs) for carrying cubic (lightweight) freight up to 68.5 tonnes on high quality duplicated road (VicRoads, 2013). These HPFVs are no heavier than a standard B-double. The policy does not specially define what a HPFV should look like. Rather, industry can design a configuration that suites their needs as long as it meets the Performance Based Standards.

HPFVs are currently restricted to high standard divided roads in Victorian regional areas and specific urban freeways (State Government of Victoria, 2013). For exclusive operation within metropolitan Melbourne, HPFVs have a limit of 30m in length. Vehicles in this range include the Super B-Double that can transport 2 forty foot shipping containers. Such vehicles provide a substantial increase in capacity compared with the B-Double that can transport both a 20 foot and 40 foot shipping containers.

There are a number of key safety features relating to the implementation of HPFVs. Vehicles must be approved under the PBS scheme and be fitted with GPS through the national Intelligent Access Program (IAP). HPFVs on the network are restricted to a speed of 90 km/h and access through the CityLink and EastLink tunnels is limited to 30m. Vehicles must have an anti-lock braking system on all axles. They must have front and rear signage to identify them as a "long vehicle". First and Last mile assessments are also required to be undertaken on arterial and local roads.

Vicroads has developed a three stage process for First and Last Mile assessment of these combinations. Stage 1 involves a desktop study. A swept path overlay analysis is conducted in Stage 2. Stage 3 involves a physical trial of the combination vehicle.

Stage 1 is a desktop study that includes a mix of checking aerial photographs of the route with Google Maps and conducting a more detailed analysis with the PBS Route Assessment Tool developed by ARRB. This tool allows road agencies and local councils to determine whether a route can accommodate a PBS vehicle. From this study it can be determined reasonably quickly whether a 30m vehicle will be access the First or Last Mile route. For example, it is easy to see from an aerial photograph whether an intersection is wide enough for larger vehicles. If it's not clear from this check whether the vehicle will be able to make the right or left hand turn safely then Stage 2 is undertaken.

Stage 2 involves an accredited PBS Assessor being commissioned by the customer to undertake a swept path overlay for the nominated routes. This can be done using intersection drawings or using Google Earth maps. With these overlays the PBS investigator is looking for instances where the HPFV encroaches into another lane during a turn. The PBS assessor then provides VicRoads with a report which includes all the overlay drawings and provides recommendations on each intersection. Approval will be given to routes where the vehicle safely finishes the turn without any encroachment. If VicRoads is still undecided about a specific route then a Stage 3 assessment is undertaken.

Stage 3 requires a single trip permit to be issues and a physical trial of the vehicle is performed. Vicroads officers determine whether the vehicle encroaches in lanes. Videos of the vehicle's movement are examined. This assessment also considers whether the vehicle can complete the move during the signal phase period of traffic signals.

First and last mile access on local council roads require written permission from the respective Council. Here Local Councils are deemed as Road Managers with the power to approve or deny access on Local Council roads.

4.5. Safety Benefits

Table 10 shows that in addition to the reduction of on-road exposure for freight vehicles, HPFVs have been demonstrated since 2005 to have substantial direct safety benefits from improved on-road safety performance when compared to conventional vehicle combinations (VicRoads, 2013).

Table 10 Safety Benefits of HPFVs

Vehicle Type	Crashes per 100 million kilometres	Crashes per 10,000 vehicles
Single semi-trailer	20.6	146
B-double	7.3	121
B-triple	4.3	99

Source: VicRoads, 2013

4.6. Intelligent Access Program

The Intelligent Access Program (IAP) provides a cost effective approach to road freight management that utilizes GPS to monitor heavy vehicles' compliance with access conditions. IAP gives transport operators flexible access to Australian roads to suit their business and operational needs as well as increasing regulators' confidence heavy vehicles are complying with agreed access conditions. Non-compliance reports are sent to Road Authorities. IAP allows vehicle and trailer identification as well as the position to be tracked allowing spatial/route compliance. For HPFVs the IAP ensures a reduction in infrastructure wear as well as better management of public expectations.

5. Conclusions

The analysis presented in this paper shows that significant benefits can be achieved by the take-up of PBS vehicles. Case studies show a lowering of several key freight exposure metrics, which involve kilometres, trips, task travel time and vehicle numbers. Productivity measures are also important, but the exact cost relationships against such productivity gains, is often only assessable on a case by case basis. Productivity improvements in general have ranged by between 20% to 50% for particular PBS vehicle types, seeded into specific network operations.

HPFVs are currently restricted to high standard roads and a detailed assessment of first and last mile access on local roads must be undertaken. However, the case studies presented illustrate that PBS and HPFVs can provide substantial savings in transport operating costs for common types of urban freight networks. They are also leading to reduced fuel consumption, emissions and crashes are becoming an effective City Logistics scheme.

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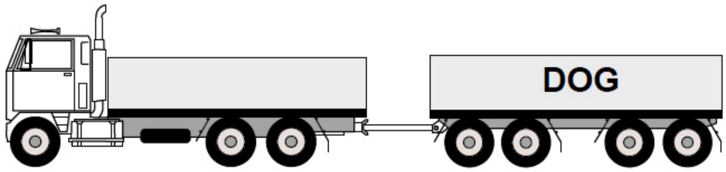
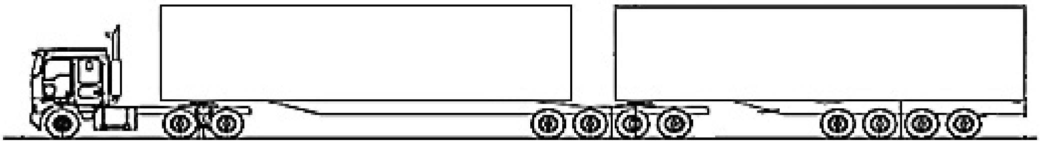
Appendix A

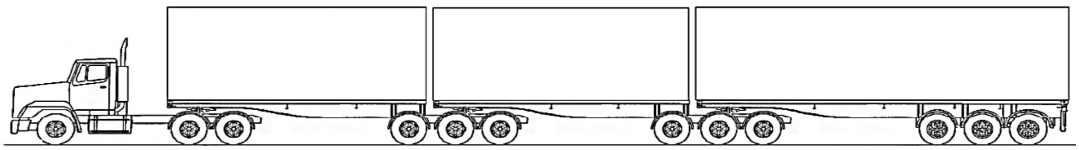
3 Axle Rigid Truck and 4, 5 or 6 axle Dog Trailer



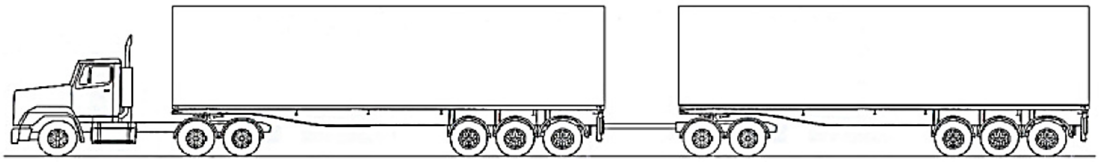
(19M to 26M)
Quad Quad Super B Double



(up to 30M)
B-Triple

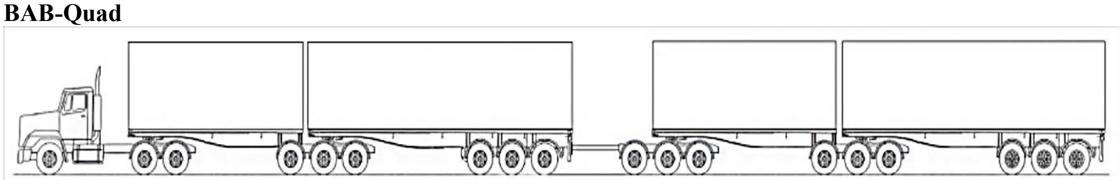


(up to 36.5m often <33m)
Type 1 Road Train



(up to 36.5m. If <30m often referred to as an A-Double)

BAB-Quad



(up to 53.5m) Some outer large city regions to Provincial cities

ABB-Quad